Lecture 13
March 1, 2005

Know:

1. The nature of electric charge
2. Coulomb's law describing the electronic force.
3. The distinction between insulators and conductors.
4. The definition of electric field.
5. The definition of electric potential.

Understand:

1. How objects acquire charge.
2. The inverse square law dependence of electrostatic force on distance between charges
3. How to draw electric field lines
4. How to calculate electrostatic potential energy.
5. How to charge an object by induction.

The temperature of a 50 g sample of aluminum is raised from 20°C to 90°C when 770 cal of heat is added. The specific heat capacity of the aluminum is

A. not calculable from this data
B. 0.11 cal/g C°.
C. 15.4 cal/g C°.
D. 0.22 cal/g C°.
E. 0.91 cal/g C°.

The three processes by which heat energy is transferred between objects are

A. heat, calorie and radiation.
B. radiation, temperature, and convection.
C. absorption, radiation, and convection.
D. radiation, convection, and conduction.
E. radiation, absorption, and conduction.

A mixture consists of 60 g of ice and 40 g of liquid water, both at 0°C. The amount of heat that must be added to melt all of the ice is about

A. 3200 cal.
B. 4000 cal.
C. 4800 cal.
D. 8000 cal.

Compared to the magnitude of the charge on a proton, the magnitude of the electrical charge carried by an electron is

A. about the same.
B. exactly the same.
C. is only 1/2 as large.
D. is only 1/3 as large.

An electron situated near another electron would feel

A. a repulsive electrical force.
B. an attractive electrical force.
C. a repulsive magnetic force.
D. an attractive magnetic force.
E. no forces from the other electron.

An atom has

A. just as many electrons as protons.
B. no neutrons in the nucleus.
C. more protons than electrons.
D. as many electrons as protons and neutrons combined.
E. at least 1 neutron.

The electrical force between any two charged objects is

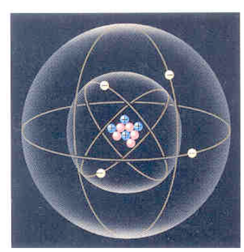
A. always attractive.
B. always repulsive.
C. always balanced by the action-reaction forces.
D. dependent on the sign of the charge on each object.

If the distance between two spherical charged objects increases by a factor of two, then the electrical force between the objects

A. decreases by a factor of four.
B. is half as big.
C. does not change.
D. doubles.
E. increases by a factor of four.

Constituents of Matter

- Matter is composed of ATOMS.
- Atoms are composed of PROTONS, NEUTRONS and ELECTRONS.
- Electric CHARGE is an intrinsic property of protons and electrons.



- **Electrostatic forces** hold the world of atoms and molecules together in perfect balance. Without this electric force, material things would not exist.

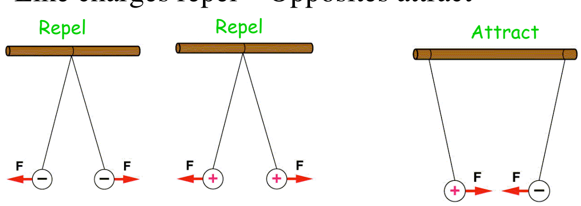
Static Electricity in Everyday Life

- Bolts of lightning dash across the evening sky during a thunderstorm.

- Clothes tumble in the dryer and cling together.
- You walk across the carpet to exit a room and receive a door knob shock.
- You pull a wool sweater off at the end of the day and see sparks of electricity.
- And most tragic of all, you have a bad hair day.

Electrical Charges

- Two type of charges exist.
- Call them positive and negative.
- Like charges repel – Opposites attract



Fundamental Charges

- Charge is measured in COULOMBS (C).
- The electron has a charge of

$$-e = -1.60\times10^{-19}C$$

- Likewise a proton has a charge of

$$+e = 1.60\times10^{-19}C$$

- The charge on an electron is the smallest amount of free charge. Every other charge is a multiple of this. Charge is QUANTIZED:

$$Q_{total}=-N_{electron}\,e\ +N_{proton}\,e$$

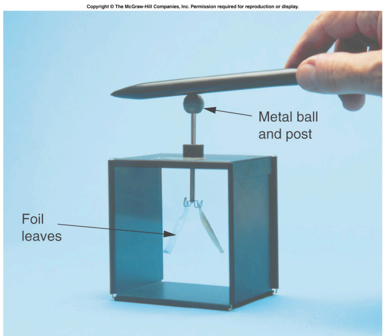
where N is the number of electrons or protons in the material

Conservation of Charge

- Charge is neither created or destroyed.
- What we call charging is either,
  - Transfer of charges, or
  - Internal rearrangement of charge carrying units
- Uncharged (neutral) objects have equal amounts of positive and negative charge

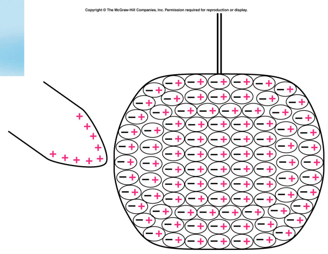
Conductors and Insulators

- A **conductor** is a material that permits the motion of electric charge through its volume. Examples of conductors are copper, aluminum and iron. An electric charge placed on the end of a conductor will spread out over the entire conductor until an equilibrium distribution is established.
- In contrast, electric charge placed on an **insulator** stays in place: an insulator (like glass, rubber and Mylar) does not permit the motion of electric charge



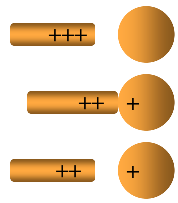
Electroscope

Insulator

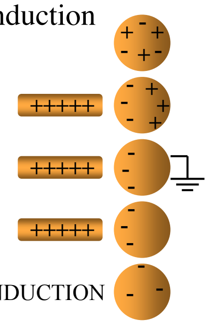


Charging Different Materials

- Two processes can be used to charge materials conduction and induction

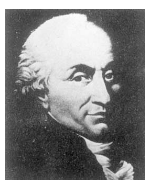


CONDUCTION

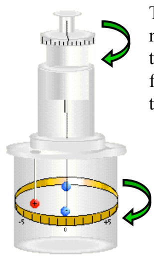


INDUCTION

Electrostatic Force



- **French physicist Charles Coulomb (1736 - 1806) experimented with electric force between point charges.**
- **Coulomb invented a delicate torsion balance with which he was able to measure the forces between charged objects**
- **Experiments demonstrated that**
  - **the greater the charge the greater the force.**
  - **the closer the charges are to each other, the greater the force.**



This dial measures the torque in the fibre and thus the force

This dial measures the separation of the charges

Coulomb's Law

- Experiments by Charles Coulomb have shown that the electric force exerted by one charge upon another is proportional to the magnitude of the charges and inversely proportional to the square of the distance (r) between them.

$$F_e = k\frac{q_1 q_2}{r^2} \qquad k = 9\times10^9\, Nm^2/C^2$$

q_1 q_2 are the charges in Coulomb

- **Like charges repel, opposite charges attract.**